Enclosure 2

U. S. ARMY ENGINEER
GEODESY, INTELLIGENCE AND MAPPING RESEARCH AND DEVELOPMENT AGENCY
FORT BELVOIR, VIRGINIA

ENGGM-IN

30 November 1964

SUBJECT: Preliminary Tests on Change Detector

TO: Project Engineer

Inclosed is a copy of a report "Results of Preliminary Tests of the Change Detector". These tests were made at the [redacted] prior to delivery. There was insufficient time before delivery to run the tests as originally planned, so some procedures had to be modified and some tests omitted. Some of the components were not operating at that time either. It is planned to make the tests again when the Change Detector is in full operating status.

[redacted]

Incl: Rept

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RESULTS OF PRELIMINARY TESTS OF THE CHANGE DETECTOR

September 1964

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GIMRADA

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A test program was prepared several weeks prior to the testing period. Because the Change Detector was delivered without allowing adequate time for the testing, some of the procedures had to be modified or omitted, and the tests were made hurriedly without adequate checking for verification. Some of the components were not operating at the time. All the tests, plus the others in the original test program, should be run again after delivery and final adjustment, which could modify some of these characteristics which have been measured.

1. Resolution
2. Frame Counter Accuracy
3. Measurement
4. Distortion
5. X-Y Movement
6. Orientation
7. Sensitivity
8. Signal/Noise Ratio
9. Shadow and Cloud Rejection
10. Correlation
11. Durability
12. Tip and Tilt Adjustments
13. Film Transport
14. Scale Adjustment
15. Optics
16. Human Engineering
17. Magnification

1. RESOLUTION

A. Design Goal: 50 lines/mm at maximum magnification.

B. Method of Measurement: The small portion of the USAF 1951 resolution pattern had been duplicated on film in 13 positions on a 70 mm frame for use in the Change Detector. Measurements were made only at the center position. This was a high contrast negative (white bars on black background).

C. Test Limitations: Measurements were made only at the center position, where maximum values are obtained. Lenses and mirrors were still dusty and dirty. The image on the monitor screen was not in focus at maximum magnification.

D. Results: Resolution was measured as 22.6 lines/mm. Three people read the 4-4 line group, which is 22.6 lines/mm, near ~~at~~ maximum magnification. At minimum magnification the resolution was 7.13 lines/mm (2-6 group readable).

E. Further Testing: Additional testing is needed at the center position as well as positions away from the center of the optical path. The resolution obtained was only about half the design goal. Considerably better results are expected when final results are made on the focusing coil and the optical elements are cleaned.

2. FRAME COUNTER ACCURACY

A. Design Goal: For 250-foot roll with frame length over 5.5 inches, error less than 1 frame. For 250-foot roll with frame length of 2-1/4 inches, maximum error of 5 frames at end of roll.

B. Method of Measurement: The above limitations are based on a maximum error of .01 inch in the measurement of frame lengths. 62.5 feet was measured off on a roll of film. This is 25 frames of 30-inch length and 333.3 frames of 2-1/4 inch length. Film was run through Change Detector and frames counted for these two sizes.

C. Test Limitations: None.

D. Results:

(1) 30-inch Frames. Counting off 25 frames, the film was 2/3 inch short, of the 62.5 foot mark (checked 3 times). This is equivalent to 2-2/3 inches in 250 feet, or less than 1/10 frame off.

(2) 2-1/4 inch Frames. 334 frames were counted in 62.5 feet. This count was checked three times. Error is 2/3 frame in 62.5 feet, equivalent to less than 3 frames in 250 feet.

E. Further Testing: This test was adequate for these format sizes to show the accuracy of measurement. After any changes are made to set in frame lengths, the counting accuracy for that setting should be checked.

3. MEASUREMENT.

A. Design Goal: 1/4 mm (approximately .01 inch).

B. Method of Measurement: These measurements were made by using the film drive. The vertical cross-hair was positioned over the first point. The film was advanced until the second point was under the cross-hair, which had not been moved. Distance between the two points was shown in millimeters in the counter showing the distance that the film has moved. Measurements were made on both the left and right films.

C. Test Limitations: Measurements were also made by keeping the film in place and moving the horizontal and vertical cross-hairs, but the measurements were 81% to 96% of the actual distances. The Goodyear Project Engineer said that the cross-hair movements had not yet been correlated with the dials to properly show the movement in millimeters. These measurements were of no value, except to show that the dial was not properly adjusted, so they are not reported in detail here.

D. Test Results:

(1) Left Film.

(a) Film movement: 36.0 mm.

Measured Distance: 35.3 mm

(Same results were obtained by viewing left film on right screen)

(b) Film movement: 80.0 mm

Measured Distance: 80.0 mm

(c) Film movement: 80.0 mm

Measured distance: 80.0 mm

(2) Right Film.

(a) Film movement: 26.0 mm

Measured Distance: 26.5 mm

(b) Film movement: 26.0 mm

Measured distance: 26.5 mm

(c) Film movement: 58.0 mm

Measured distance: 58.5 mm

(d) Film movement: 59.0 mm

Measured distance: 58.5 mm

E. Further Testing: Measurement accuracy must be determined using the cross-hair movements and dials.

4. DISTORTION.

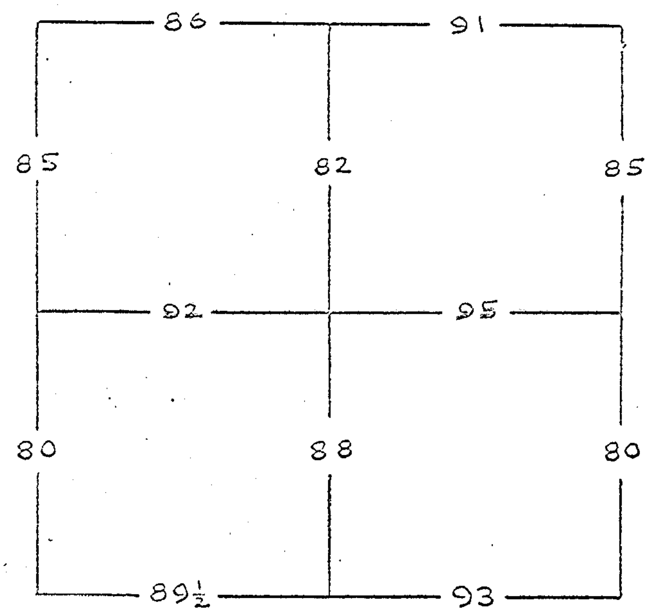
A. Design Goal: Not specific.

B. Method of Measurement: A square grid pattern was put into the aperture and viewed on the screen at low magnification. Distances were measured on the surface of the monitor tube of the sides of four equal quarters of a square (see Figure 1). This was done with an image in the left aperture and then with an image in the right.

C. Test Limitations: There may be some slight errors of measurement, possibly 1 mm, because of curvature of the surface of the monitor tube. Such errors should generally be consistent, however; the observer's eye was kept perpendicular to the center of the screen for all measurements.

D. Test Results: The measured results are shown on the diagrams on Figure 1. The square used in the right aperture was a little smaller than that used in the left, so there is no significance in the fact that the values shown for the right film are smaller. The measurements for each, however, show that there are significant distortions in various portions of the images. These distortions should have no effect on accuracy of measurements as the cross-hairs are subject to the same distortions as the points they overlie.

LEFT FILM



The figures shown are the measurements in millimeters of distances between the points which represent squares on the film.

RIGHT FILM

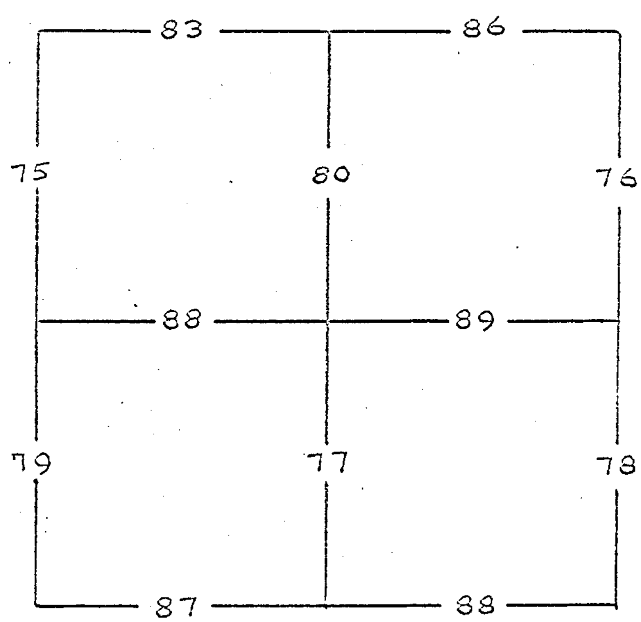


FIGURE 1

E. Further Tests: Additional tests should be made to see if these distortions are consistent, the effects they might have on measurement accuracy, and the effects of magnification and raster movement on distortion.

5. X-Y MOVEMENT

A. Design Goal: Not specific.

B. Method of Measurement: Images in both channels were made by using the manual knobs, and change the horizontal and vertical positions of the image on the monitor. Automatic operation of X and Y movements was also observed.

C. Test Limitations: None

D. Results: The images in each channel could be moved approximately half the width of a square frame in both X and Y directions. It took 12 seconds to move an image from one extreme position to the other. The movement by manual control performed satisfactorily. After the automatic correlation process, the images were sometimes displaced from the proper positions for registration. This may have been an X-Y error or possibly orientation.

E. Further Testing: Tests should be made to determine the accuracy of the manual setting for the automatic correlation to operate.

6. ORIENTATION

A. Design Goal: ± 180° for the right image.

B. Method of Measurement: Comparative cover with different orientations was put into the two apertures. Right image was rotated both manually and automatically.

C. Test Limitations: None.

D. Results: The right image was rotated manually 180° both directions from its normal position. It takes about 23 seconds to rotate through 180°. The manual knob turns "faster" than the image does. If the knob is turned fast and then stopped, the image keeps turning until it gets to the orientation as set in by the knob. Manual operation was satisfactory. After the automatic correlation sequence, the images did not always go back to proper registration. This may have been due to improper operation of the X-Y movements on the orientation.

E. Further Testing: Tests should be made to determine the accuracy required for the manual orientation setting for the automatic correlation to work properly.

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7. SENSITIVITY.

Specific measurements were not made. A one-level difference on a 12-level gray scale could be noted, but the edges were sharp and apparent. In random patterns such a small difference in tone change would probably not be detected.

8. SIGNAL/NOISE RATIO. 10:1 , 15:1 - Oscilloscope

No tests were made.

9. SHADOW AND CLOUD REJECTION.

The shadow and cloud rejection components were not wired in to operate.

10. CORRELATION

A. Design Goal: 2 min (maximum)

(NOTE: Original design called for simultaneous advance of both films one square frame at a time. Initially, the operator manually adjusts settings to the approximate correlation, then the automatic sequence is actuated. After the initial setup, corresponding frames would be very closely aligned and the search portion of the automatic sequence could be eliminated, cutting the time to less than 30 seconds. A contract modification called for new film magazines with high speed movement to handle panoramic formats on unperforated film. Film advance is not simultaneous, so the approximate manual setting must be made each time, which requires the full automatic sequence each time. Thus, the conditions for rapid automatic correlation after the first frame no longer exists; and the second design goal given in the proposed test program, 30 seconds per frame after the first frame, is not applicable).

B. Method of Measurement: Comparative cover was positioned in the two apertures and approximate alignment performed manually for the X and Y positions, scale, and orientation. The button for automatic correlation was pressed, and the time was recorded for the automatic correlation sequence.

C. Test Limitations: After the automatic correlation sequence was completed, one gear did not always return to its proper position for proper correlation. With a nudge from a finger, it would go into position however. This required final adjustments that had not yet been made. It apparently had no effects on the results measured, however.

D. Test Results: It takes 1 minute and 20 seconds for the automatic correlation sequence; four measurements were made to check this.

E. Further Testing: No further special testing for timing is required. Tests are needed to check the accuracy of correlation, however, and the effects of certain conditions which indicate changes which are not there. Apparently, the effects of slight tip or tilt indicate minute changes. The existence of tip or tilt is frequently not known and difficult to correct.

11. DURABILITY

No measurements made. Many of the components of the Change Detector have been operating for extensive periods of time, but all the components have not been operating at one time.

12. TIP AND TILT ADJUSTMENTS

A. Design Goal:

(1) Tip, ± 5° along flight line.

(2) Tilt, ± 5° laterally.

B. Method of Measurement: Tip and tilt corrections are not part of the automatic correlation process. Any tip or tilt corrections must be made manually. Each filmholder was adjusted to a "neutral" position, then moved to the extreme position in each direction of movement and the maximum angular motion was measured.

C. Test Limitations: None.

D. Tests Results:

(1) Tip, left film. Film holder moved satisfactorily 5° in both directions from its normal position.

(2) Tilt, right film.

E. Further Testing: Tests are needed to check the effects on correlation of having incorrect tip and tilt settings. Index marks for 0 tip and tilt should be placed on the control panel next to the dials. (Comment: Frequently tip and tilt are unknown, so sometimes it cannot be pre-set on the Change Detector. It may not be evident that tilt exists in the imagery until after the correlation sequence has been completed. Then some evidence of mis-match may show, which might be due to tilt or to perspective or elevation differences. It is very difficult for the observer to be sure he is using the best settings for tip and tilt.)

13. FILM TRANSPORT

A. Design Goal:

(1) Low range - 0 to 0.2 in/sec (1.0 ft/min)

(2) High range - 0 to 24 in/sec (120 ft/min)

B. Method of Testing:

(1) Time was measured that it took to move 2.5 feet of film through the aperture at the maximum speed in the low range.

(2) Time was measured that it took to move 62.5 feet of film through the aperture at maximum speed.

C. Test Limitations: None.

D. Test Results:

(1) Low range

2.5 feet in 2 min 17 sec and repeated in 2 min. 17 sec.

Speed = 0.21 in/sec or 1.06 ft/min.

(2) Fast range.

62.5 feet in 29.2 sec and in 29.06 sec (ave. 29.13 sec)

Speed = 2.15 ft/sec or 129 ft/min

E. Further Testing: No further special testing is required.

14. SCALE ADJUSTMENT

A. Design Goal: Correlation should be possible if the scale of one film is 2 times the scale of the other.

B. Method of Measurement: Grid patterns at the same scale were positioned in the two apertures and correlated. The scale knob was then turned in a clockwise direction as far as it would go. This makes one image larger on the screens and the other smaller. Distances between the same points were measured on both screens and the ratio completed. The knob was then turned to its farthest counterclockwise position. This has the reverse effect; it makes the first image smaller and the other one larger. Similar measurements were made.

C. Test Limitations: None.

D. Results:

(1) Clockwise

$$\frac{15.0}{8.0} = 1.875$$

(2) Counterclockwise

$$\frac{14.0}{8.0} = 1.75$$

0.571

(3) Manual operation of the scale adjustment was satisfactory. Although the automatic correlation did not always result in proper positioning for registration, it did not appear to be off in scale factor.

E. Further Testing: A test should be made to measure the total scale factor from the counterclockwise position of the knob to the clockwise position. The total scale adjustment is a combination of the factors above.

15. OPTICS

A. Design Goal: Not specific.

(Design goal for resolution of 50 lines/mm at maximum magnification with respect to the transparency. No specific figures for the optics alone.)

B. Method of Measurement: The resolution of the optical paths between the films and CRT scanners was determined by placing the standard USAF resolution pattern in the aperture and positioning a microscope in front of the mirror just above the CRT.

C. Test Limitations: None.

D. Results: The "6-2" set of bars could be distinguished, representing a resolution of 71.9 lines/mm.

E. Further Testing: No further special testing is required.

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16. HUMAN ENGINEERING

A. Design Goal: Not specific.

B. Method of Measurement: Only initial comments and suggestions are given here. No specific tests were run for this subject.

C. Test Limitations: Not applicable.

D. Results:

(1) Panel Lighting. Punch switches are back-lighted. Labels are back-lighted, clear lettering on black-painted panel. Labels and switches generally show up clearly, except for the dials for cross-hair indicators which are inadequately lighted.

(2) Use of the terms cloud and shadow rejection may be confusing. Other dark and light areas are also rejected. The use of other terms may be desirable.

(3) Flicker appears to be very useful. It seems to make changes more obvious than the video difference presentation does. Continued use of it may strain the eyes some, but using it for a little while seems to be all right.

(4) Chains should be put on loading screws, so they won't fall to the bottom of the cabinet. Protection is needed to keep other objects from falling on the CRT and other fragile components.

(5) Use of the terms "left" and "right" films is better than the original plan of calling them the "reference" and "comparison" films.

E. Further Testing: Observations will continue to be made during the testing and operating periods to observe the efficiency of operations and to suggest improvements that could improve the operation of the Change Detector.

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17. MAGNIFICATION

A. Design Goal:

Minimum: 5X

Maximum: 200X

B. Method of Measurement: Grid pattern was placed in the left aperture and presented on the screen. Distance was measured on the monitor between two points and the distance between the same two points was measured on the film. This was done for both the minimum and maximum settings.

C. Test Limitations: Only one set of measurements was taken with the film in one aperture.

D. Results:

(1) Minimum:

Distance on film: 1-7/32 inches

Distance on monitor: 4-3/4 inches

Magnification $= \frac{4.75}{1.219} = 3.91$

(2) Maximum:

Distance on film: $\frac{39}{32}$ (25) inches

Distance on monitor: 9-1/8 inches

Magnification $= \frac{9.125}{.04875} = 187.1$

E. Further Testing: Results should be obtained with the film in each of the apertures.

Final Acceptance Tests on Change Detector

These tests were performed [redacted] over a period of several months.

- D R A F T -

3 December 1965

1. RESOLUTION.

A. Design Goal: 50 lines/mm at maximum magnification.

B. Method of Measurement: An original film transparency of the USAF 1951 Resolution Pattern was used. Readings were taken from both screens with the pattern in the left aperture, then from both screens with the film in the right aperture. The pattern was centered in the aperture, and the image was positioned at one of the 9 positions on the screen (See Figure 1) with the X and Y control knobs. Readings were taken at each of these 9 positions.

C. Test Limitations: Resolution measurements were made with magnification set to produce optimum results. This was less than maximum magnification, which caused the image to be fuzzy.

D. Results: Results are shown on Figure 1, which shows the maximum resolution at 9 positions on the screens, with the images magnified to give the best results. The resolution was measured on both screens for all positions. When the film was in the right aperture, however, higher results (25.3 lines/mm) were obtained than when the film was in the left aperture (22.6 lines/mm). Resolution measurements were also made with the image on the screen at minimum magnification (3.9X), and results are shown on Figure 2. Again, both screens produced the same measurements. Readings were also higher with the film in the right aperture than in the left. In both cases resolution was highest at the center and lowest in the corners.

MAXIMUM RESOLUTION
(Magnified to Give Best Results)

Right Film - Same Resolution on Both Screens

25.3	25.3	25.3
25.3	25.3	25.3
25.3-	25.3	25.3

Left Film - Same Resolution on Both Screens

22.6	22.6	22.6
22.6	22.6	22.6
22.6	22.6	22.6

FIGURE 1

RESOLUTION AT MINIMUM MAGNIFICATION (3.9X)

Left Film - Same Resolution on Both Screens

4.00	4.49	4.00
4.49	5.04	4.49
3.56	4.00	4.00

Right Film - Same Resolution on Both Screens

4.00	5.04	4.00
4.49	5.66	5.04
4.49	5.04	4.49

FIGURE 2

2. FRAME COUNTER ACCURACY.

A. Design Goal: For a 250 foot roll with frame lengths over 5.5 inches, error less than 1 frame. For a 250 foot roll with frame length of $2\frac{1}{4}$ inches, maximum error of 5 frames at end of roll.

B. Method of Measurement: There are 4 settings that can be made for frame lengths to be used as the basis for frame counting. An electronics technician, not the operator, makes these settings in the back of the Change Detector. The settings for frame sizes are set by "trial-and-error." The settings are adjusted until the counter is within limits. Listed below are the frame lengths which were set as prescribed by the using Agency and the number of frames in a 62.5 foot length for these respective frames:

61.7 mm	308.75 frames
270.7 mm	70.37 frames
766.7 mm	24.84 frames
791.2 mm	24.08 frames

The operator may select any one of the above four frame lengths he desires by means of a control knob.

After the final adjustments were made to the settings for frame lengths, each count was checked three times.

D. Test Results:

(1) Frame Length 61.7 mm (2.43 in.)
Counter Readings 310
Actual Count 309
Error 1 frames in 62.5 feet
Equivalent to 4 frames in 250 feet

(2) Frame Length 270.7 mm (10.66 in.)
Counter Readings 71
Actual Count 71
Error 0 in 62.5 ft or 250 ft.

By checking the counter accuracy more precisely using the film advance measurement, the error was determined as .03 of a frame in 62.5 ft., or

.12 of a frame in 250 feet.

(3) Frame Length 766.7 mm (30.19 in.)
Counter Readings 25
Actual Count 25
Error 0

Checking accuracy again with the film advance measurement, the error was found to be .04 of a frame in 62.5 feet, or .16 of a frame in 250 feet.

(4) Frame Length 791.2 mm (31.15 in.)
Counter Readings 23
Actual Count 24
Error 1 in 62.5 ft., or 4 in 250 feet

This frame length was set prior to the test, supposedly for 791.2 mm. By checking with the film advance measurement, it was determined that the setting has erroneously been made for 830mm. The technician was no longer present to make a final adjustment for this test.

E. Note: The counter changes from 0 to 1 as soon as the film advance is started, so the dial is reading 1 all through the first frame. It changes to 2 at the end of the first frame. So any additional portion of a frame is indicated by the counter as the next high frame.

3. MEASUREMENT.

A. Design Goal: $\frac{1}{4}$mm (approximately .01 inch)

B. Method of Measurement: Distances were measured by moving the cross-hairs both vertically and horizontally on the screen, and by using the film drive for horizontal measurements only. Measurements were made on both the left and right films, displayed on the left and right screens respectively. When the cross-hairs are used for measuring, both points must be visible on the screen; but in using the film drive, horizontal distances can be measured across an entire panoramic frame.

(1) Vertical Measurement with Cross-Hair: Points near the same vertical plane were selected on the upper and lower portions of the test frame. When the cross-hair was positioned over the respective points, the vertical dial readings were noted to obtain the indicated distances between the two points.

(2) Horizontal Measurement with Cross-Hairs: Points near the same horizontal plane were selected on the left and right portions of the test frame. When the cross-hair was positioned on the respective points, the horizontal dial readings were noted to obtain the indicated differences between the two points.

(3) Horizontal Measurement with Film Movement: Points near the same horizontal plane were selected for measurement. The cross-hair was positioned over the first point, and the dial was zeroed. The film was advanced until the second point was under the cross-hair, which had not been moved. Distance between the two points was shown in millimeters on the dial which shows the distance the film has been davanced.

C. Test Limitations: With the use of the available equipment, the actual measurements between the two points on the film were made to the nearest ½ millimeter. These distances were measured with a scale after the film was taken from the Change Detector and were used to check the results obtained from the dial indicators on the Change Detector.

D. Test Results: The test results are summarized on Figure 3. The same results were obtained whether viewing on the left or right screen. It will be noted that measurements were accurate within the limitations of the check measurements (½ mm).

MEASUREMENT ACCURACY

LEFT FILM	mm.	Actual Dist
Vertical Distance (Cross Hair)	42.0	42.0
Horizontal Dist (Cross Hair)	32.5	33.0
Horizontal Dist (Film Move)	41.0	41.0
RIGHT FILM		
Vertical Distance (Cross Hair)	30.5	31.0
Horizontal Dist (Cross Hair)	28.5	29.0
Horizontal Dist (Film Move)	29.0	29.0

(Figure 3)

4. DISTORTION.

A. Design Goal: Not specific

B. Method of Measurement: There are ten knobs on each monitor screen for making adjustments that affect the relative shape of the image that appears on the screen. Two or three hours were spent making adjustments to minimize the distortions. A square grid pattern was put into the left aperture and viewed on the screen at low magnification. Distances were measured on the surface of the monitor screens (separately) of the sides of four equal quarters of a square. The procedure was repeated with the grid pattern in the right aperture. The lengths of the sides of the squares was measured on the film with a micrometer — microscope to check distortion of the grid on the film. With the "center-right" line considered as 1 for all cases, the ratios of all the lines measured were computed to make comparison easier.

C. Test Limitations: There may be some small errors of measurement because of parallax, curvature of the screen, and the accuracy with which the scale could be read. Errors are believed to be within $\pm$0.5 mm. When making measurements, the observer kept his eye perpendicular to each point as he noted it.

D. Test Results: Results of the distortion measurements are shown on Figures 4 and 5. All lengths have been converted to ratios by dividing the measured lengths of each line by the length of the line from the center position to the right side of the respective squares. Line A, as marked on the figures was used as the denominator in computing these ratios. These resulting values are shown in parentheses on the respective lines. Because the monitor images are being compared with the grid on the film which is distorted(as indicated by to top diagrams on the figures) relative length (ratios in parentheses) of each line on the monitor is divided by the relative length of each corresponding line on the film grid. These values, which indicate the ratio of each line on the grid on the screen to the respective line on the actual film grid. If there is no distortion, this value should be 1.00.

Figure 4. DISTORTION
Film In Left Channel

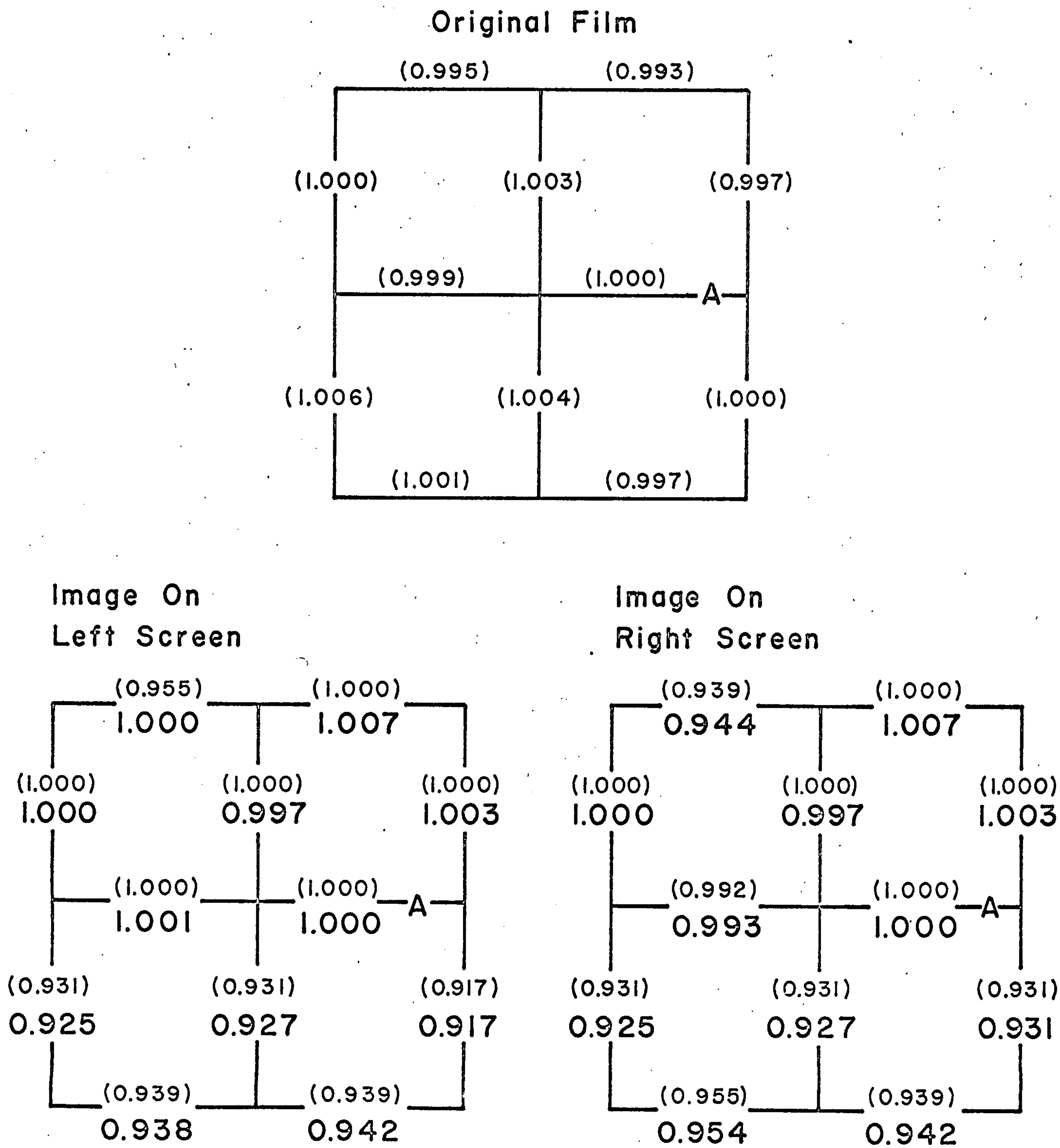
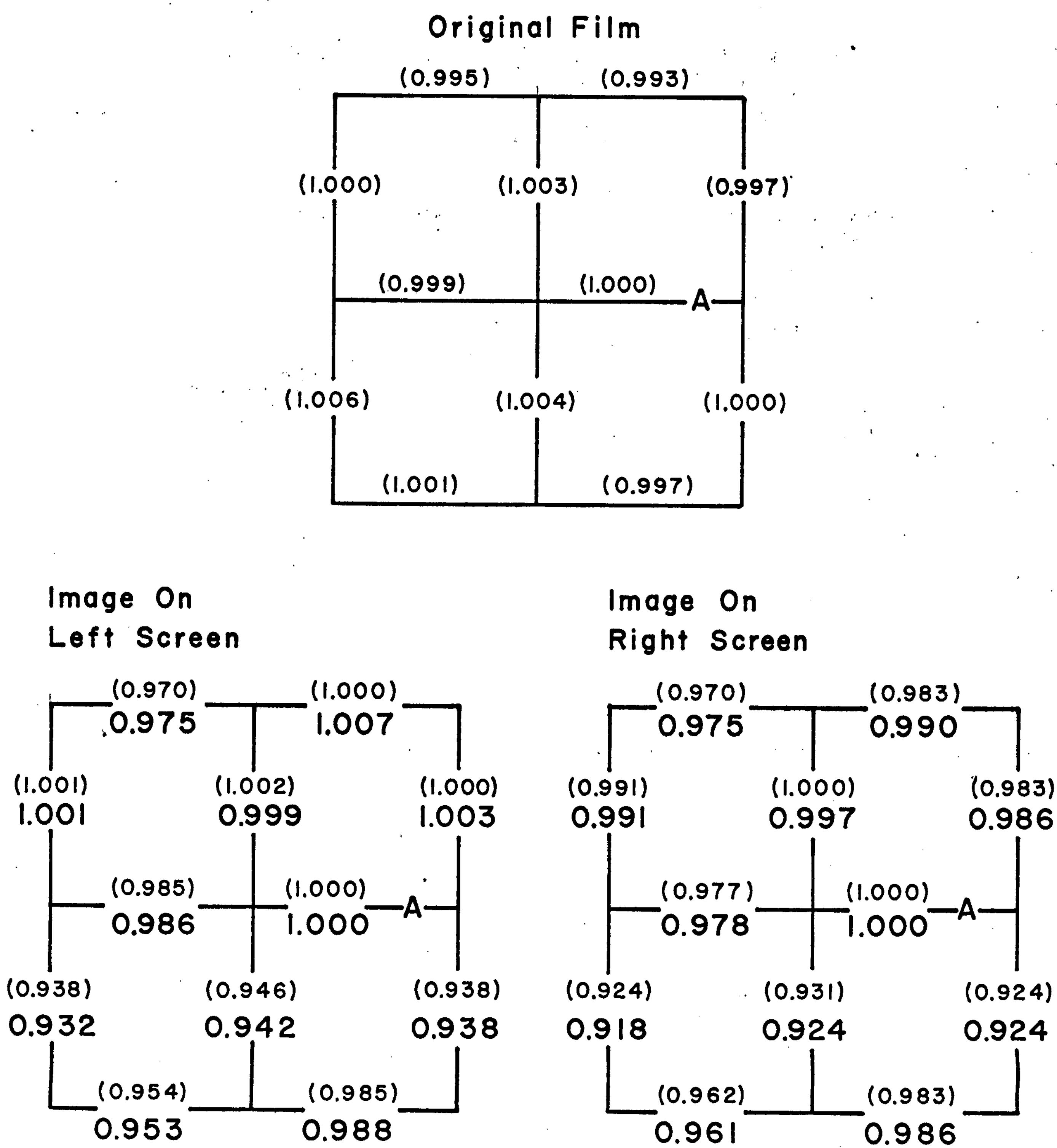


Figure 5. DISTORTION.
Film In Right Channel



5. X - Y MOVEMENT.

A. Design Goal: Not specific

B. Method of Measurement: The X and Y manual control knobs were used to manipulate the images on the monitor. Automatic operations of the X and Y movements were also observed.

C. Test Limitations: None

D. Test Results: The images in each channel could be moved approximately half the width of a $2\frac{1}{4}$ inch square frame in both X and Y directions. It took 12 seconds to move an image from one extreme position to the other. The movement by manual control performed satisfactorily. After the automatic correlation process, the images were sometimes displaced from the proper positions for registration. In some cases, this appeared to be due to improper X-Y correlation.

E. Further Testing: Tests should be made to determine the accuracy required for the manual X-Y settings for the automatic correlation to operate properly.

6. ORIENTATION.

A. Design Goal: $\pm 180^\circ$ for the right channel.

B. Method of Measurement: Film was placed in the right channel, and the image observed as the orientation manipulations were made. Comparative cover was used in the two channels to check the orientation operation during automatic correlation.

C. Test Limitations: None. Attention is called to the fact that there is no rotation in the left channel.

D. Test Results: The image from the right channel was rotated manually 180° both directions from its normal position. It takes 23 seconds to rotate through 180°. The manual knob turns "faster" than the image does. If the knob is turned fast and then stopped, the image keeps turning until it gets to the orientation as set in by the knob. Manual operation was satisfactory. After the automatic correlation sequence, the images did not always go to proper registration. This was frequently due to improper orientation, although the X-Y operation may have also been a contributing factor.

E. Further Testing: Tests should be made to determine the accuracy required for the manual orientation setting for the automatic correlation to work properly.

7. SENSITIVITY.

A. Design Goal: Not specific

B. Method of Measurement: A pattern of various shapes and sizes was prepared, which consisting of light and dark shades: This was reproduced on 70mm film. Several changes were made in the original pattern, small areas were darkened, and the changed pattern was reproduced, The two frames were placed in the apertures and correlated to note the results on the monitor. Density unit measurements were made of two points before and after changes, using a Quanta-log Transmission Densitometer.

C. Test Limitations: None

D. Test Results: Two points, A and B, were selected for measurements. At point A the change was easily noted; at point B the change was barely noticeable. The density readings(percentage of transmittance expressed in density units) were as follows:

	Point A	Point B
Before	0.67	0.65
After	0.54	0.60
Difference	0.13	0.05

If the density difference is less than 0.05, it is doubtful that the difference, or change, would be detected by viewing the video-difference image on the Change Detector.

8. SIGNAL/NOISE RATIO

No tests were made. These measurements will have to be made after new power amplifier unit has been installed.

9. SHADOW AND CLOUD REJECTION.

A. Design Goal; Not specific. It was intended, however, that the electronic clipping technique would enable the operator to eliminate from the display any object beyond certain light intensities. Generally, the brightest areas on a pictures are clouds if any are present; and usually the darkest areas are shadows. This technique would keep the clouds and shadows from being indicated as changes when using the video difference technique.

B. Method of Measurement: A transparency with clouds showing was placed in the aperture with the Cloud Rejection knob at maximum. The knob was turned slowly to reduce the cutoff level. For shadow rejection, a transparency with dark shadows was used and the rejection level raised slowly.

C. Test Limitations: It should be noted that the generalizations assumed above (clouds are the lightest part of an airphoto, and shadows are the darkest spots) are not always true. This should not affect the test results, however, as the rejection circuitry should reject all objects on the basis of the light levels.

D. Test Results: The cloud and shadow rejections did not operate satisfactorily, although the cloud rejection performed better than the shadow rejection did. By clipping the clouds completely, however, some of the other detail is also eliminated. Sometimes there was an unclipped band across a cloud area. For shadows a 1 - inch band across the lower part of the screen was rejected first, then the image reappeared as the control knob was turned further. There were many unclipped strips across dark portions of the film image. Sometimes when an object was rejected, the entire horizontal scans through the object were also rejected. There was no usable information obtained by using the shadow rejection. Much of the erroneous action is probably due to the noise level on the display system. This will be largely alleviated when the present power unit is replaced with one of greater output.

10. CORRELATION.

A. Design Goal: Two minutes maximum for automatic correlation (Note-Original design called for simultaneous advance of both films one frame ($2\frac{1}{4}$ inch square) at a time. Initially, the operator manually adjusts settings to the approximate correlation, then the automatic sequence is actuated. After the initial ~~xxxxx~~ setup, the subsequent frames would be very closely aligned and the search portions of the automatic sequence could be eliminated, cutting the time to less than 30 seconds. A contract modification called for new film magazines with high speed movement to handle panoramic formats on unperforated film. Film advance is not simultaneous, so the approximate manual setting must be made each time, which requires the full automatic sequence each time. Thus, the conditions for rapid automatic correlation after the first frame no longer exists; and the second design goal given in the original proposed test program, 30 seconds per frame after the first frame, is not applicable.)

B. Method of Measurement: Comparative cover was positioned in the two apertures and approximate alignment performed manually for the X and Y positions, scale, and orientation. The automatic correlation was initiated by pressing the automatic button. The time was recorded for the automatic correlation process and the accuracy of the correlation was noted.

D. Test Results:

(1) The time required for the automatic correlation is 1 minute and 12 seconds. In a dozen measurements it never varied more than 1 or 2 seconds from this.

(2) The following are some comments on the accuracy of the automatic correlation for a number of separate correlations:

(a) Correlating duplicate transparencies, good for X, Y, and scale, but azimuth was off.

(b) With accurate initial manual correlation, the result was a very small error in X.

(c) This accurate initial setup was repeated, resulting in a good correlation.

(d) Scale error was set in with the approximate manual correlation. Automatic correlation resulted in a slight error in X.

(e) Small azimuth and scale errors were set in manually, automatic results were fairly good.

(f) Scale and azimuth errors were set in manually; after automatic sequence, scale was good but azimuth was off a little.

(g) Azimuth error was set in, other settings were close; results of automatic correlation were very good.

(3) Results of the automatic correlation process were not consistently good. Frequently the correlation was good, but sometimes the results were unusable. The errors after automatic correlation were often greater than those that had been set manually before the automatic sequence. There is a small error that may result because of the mechanical operation of the nutator, but results of many correlation sequences greatly exceeded this small amount.

E. Further Testing: Tests are needed to determine how close the manually setting must be for the automatic correlation.

F. It is very difficult to get accurate correlation, either manually or automatic, over an entire frame. Best manual correlation can be achieved by working with an enlarged portion of the frames.

11. DURABILITY

A. Design Goal: Not specific.

B. Method of Testing: No specific tests were made. Observations have been noted to components that required replacement.

C. Test limitations: Not applicable

D. Results: The Change Detector has had considerable use since its delivery, ranging from periods of an hour or less to periods exceeding half a day. The only major weakness has been the reduction gears of the film drive motors, which resulted in frozen bearings in several instances, which in turn damaged the windings in the fields of the motors. The reduction gears were replaced several times. After several failures, the film drive system was redesigned to overcome this. Throughout this period, there has been very little trouble with the CRT and associated electronics.

12. TIP AND TILT ADJUSTMENTS

A. Design Goals

(1) Tip, $\pm 5^{\circ}$ along flight line

(2) Tilt, $\pm 5^{\circ}$ laterally.

B. Method of measurement: Tip and tilt are not part of the automatic correlation process. Any tip or tilt corrections must be made manually. Each filmholder was adjusted to a "neutral" position, then moved to the extreme position in each direction of movement and the maximum angular movement was measured.

C. Test Limitations: None

D. Test Results:

(1) Tip, left film. From the zero position, the filmholder moved 7° to the left and 6° to the right.

(2) Tilt, right film. From its neutral horizontal position, the filmholder moved 7° forward but only 3° toward the back. The motor for the film drive keeps the filmholder from tilting back the full 5 degrees.

E. Further Testing: Tests are needed to determine the effects on correlation of having incorrect tip and tilt settings.

F. Note: Frequently tip and tilt are unknown, so sometimes it cannot be pre-set on the change detector. It may not be evident that tip or tilt exists in the imagery until after correlation has been attempted. Then some evidence of mis-match may show, which might be due to tip or tilt or to perspective or elevation differences. It is very difficult for the observer to be sure he is using the best settings for tip and tilt.

13. FILM TRANSPORT.

A. Design Goal:

(1) Low range - 0 to 0.2 in/sec (1.0 ft/min)

(2) High range - 0 to 24 in/sec (120 ft/min)

B. Method of Testing:

(1) The time was measured that it took to move 2.5 feet of film through the aperture at maximum speed in the low range.

(2) The time was measured that it took to move 62.5 feet of film through the aperture at maximum speed.

C. Test Limitations: None

D. Test Results:

(1) Low range - 2.5 feet in 2 min 33 sec (average of 8 readings) Speed - 0.196 in/sec or 0.98 ft/min

(2) Fast range - 62.5 feet in 38 seconds (same measurement 3 times) Speed - 19.7 in/sec or 98.7 ft/min

(3) In the preliminary tests the film transport speed exceeded the design goals; however, there was little control over the speed. The servo to the drive motor was changed to give greater control to obtain continuous variation of speed. This also resulted in lowering the top speed.

14. SCALE ADJUSTMENT.

A. Design Goal: Correlation should be possible if the scale of one film is 2 times the scale of the other.

B. Method of Measurement: Grid patterns at the same scale were positioned in the two apertures and correlated, the ratio of their sizes being 1:1 on the film and on the screens. The scale knob was then turned in a clockwise as far as it would go. This makes one image larger and the other smaller. Distances between the same points were measured on both images and the ratio computed. The knob was then turned to its farthest counter clockwise position. This has the reverse effect, it makes the first image smaller and the second one larger.

C. Test Limitations: None

D. Test Results:

(1) Clockwise

$$\frac{7\ 5/8}{4\ 3/8} = 1.74$$

(2) Counterclockwise

$$\frac{4\ 1/4}{7\ 5/8} = 0.577$$

(3) Total Scale Adjustment

$$\frac{1.74}{0.577} = 3.02$$

(4) Manual correlation of the scale was satisfactory. Automatic correlation did not always result in proper positioning for scale adjustment for registration.

15. OPTICS.

A. Resolution of the optical system was measured by [redacted] STAT
[redacted] STAT at the plant prior to the final assembly and delivery of the Change Detector. Results are given in "Results of Preliminary Tests of the Change Detector," September 1964. This has not been repeated since delivery because the microscope cannot be positioned in the optical path and used to read a resolution pattern when the system is within the cabinet.

B. The optical wedges were not securely mounted in their rotating members when delivered. The wedges were removed and new wedges were inserted and bonded into place with epoxy cement, their correct positioning having been determined on the optical bench.

16. HUMAN ENGINEERING.

A. There are no specific goals or tests for human engineering. This section consists of comments or suggestions concerning human factors as related to the Change Detector.

B. Control knobs are grouped and outlined by backlighted lines. At the suggestion of photointerpreters who reviewed the panel layout drawing, the two input films are designated as "Left" and "Right" films, depending on whether it placed in the left or right magazine in the cabinet. This is preferable to "reference" and "comparison" films which was originally proposed, as it doesn't make any difference which channel is used for either film and a film might be "reference" for one use and "comparison" for another.

C. The use of back-lighting for labeling and punch switches is good. Both show up clearly. The cross-hair indicators, which are not back-lighted, do not show up well. Mechanics of the present model make it difficult to service the panel lighting. All the control knobs and the units behind the control knobs have to be removed to get into the light "sandwich." The back-light panel (in 3 units now) should be a single unit with external connections.

D. Protection is needed to prevent objects from falling on the mirrors or the CRT. The addition of chains or captive screws for holding the film spool covers in place would prevent the screws from falling on the mirrors or CRT or on the bottom of the cabinet where they would be difficult to retrieve.

E. Comment by photointerpreters: The use of the terms "cloud" and "shadow" rejection may be confusing. Since other light and dark objects are also rejected, the use of other terms may be desirable.

F. Comment by photointerpreters: They feel that the flicker is very useful. Continued use of it could be a strain on the eyes, but using it for short periods is good. It seems to make the changes more obvious than the video difference does.

G. In turning the X - control knobs clockwise, the image from the right film is moved right and the image from the left film is moved left. Clockwise movement of these knobs should move images from both films in the same direction.

H. The main large control knobs are arranged as follows:

Y X Scale Y X Rot

Are the Y and X knobs in the best positions? When X and Y coordinates are given, the X value is always given first. In normal reading from left to right this would indicate the left knob for X.

J. At high magnification it is difficult to center the cross-hairs over a point. This is really not serious, as measurements with the cross-hairs can only be made to the nearest 0.1 mm. At high magnification the operator tries to position cross-hairs more accurately than the device is capable of measuring.

K. It is suggested that the flicker control knob have 4 numbered positions as there are only that many rates of speed. Flicker rates are 37, 50, 75, and 150 cycles per minute.

L. The cross-hairs sometimes creep off the points where they are positioned. Because of coarseness of the control, it is difficult to get the cross-hairs positioned over the desired point.

M. After automatic correlation, red lights indicate if correction has been made in scale and/or rotation. If the manual button is pushed while the red light is on, the scenes move back to the original setting.

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To retain the new setting the knob must be turned until the red lights are out, then the manual button is pushed retaining the automatic correlated positioning. It is desirable to have this adjustment incorporated so it cannot be lost by pushing the manual button at the wrong time.

17. MAGNIFICATION

A. Design Goal:

Minimum 5X

Maximum 200X

B. Method of Measurement: Grid pattern was placed in the left aperture and displayed on the monitor. The distance was measured on the monitor between two points and the distance between the same two points was measured on the film. For the maximum determination the distance on the film was very short, so a longer distance was measured on a uniform grid and the desired length was computed.

C. Test Limitations: Only one set of measurements was made with the film in one aperture. There was considerable distortion of the image on the monitor, so measurements were not precise.

D. Test Results:

(1) Minimum

Distance on film	1.56 in.
Distance on monitor	5.44 in.

$$\text{Magnification} = \frac{5.44}{1.56} = 3.5$$

(2) Maximum

Distance on film	0.394 in.
Distance on monitor	6.12 in.

$$\text{Magnification} = \frac{6.12}{0.394} = 156$$